U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER

DIRECT COAL LIQUEFACTION BASELINE DESIGN AND SYSTEM ANALYSIS

CONTRACT NO. DE-AC22 90PC89857

QUARTERLY REPORT

APRIL - JUNE, 1992

AUGUST, 1992
PITTSBURGH, PENNSYLVANIA

Bechtel

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August 21, 1992

U. S. Department of Energy
Pittsburgh Energy Technology Center
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Attention: Mr. Swenam Lee
Project Manager

Subject: D.O.E. Coal Liquefaction
Base Line Design and System Analysis
Contract No. DE-AC22 90PC89857
Bechtel Job No. 20952
Quarterly Status Report
Letter No. BLD-106

Dear Mr. Lee:

Attached for your information are three copies of the subject Quarterly Status Report covering the March 16, 1992 through June 21, 1992 reporting period. Copies to other members, as required by the contract are separately and directly transmitted.

Please note that all information contained herein should be considered preliminary pending issue of the final tasks reports.

If you have any questions or comments on this Quarterly Status Report please contact me.

Sincerely yours,

Syamal K. Poddar
Project Manager

Attachment

cc: Martin Byrnes, DOE/PETC
Robert Hamilton, DOE/PETC
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Gilbert V. McGurl, DOE/PETC
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1. INTRODUCTION

Effective May 16, 1990, Bechtel with Amoco as subcontractor, initiated a study to develop a computer model for a base line direct coal liquefaction design for the U.S. Department of Energy's (DOE) Pittsburgh Energy Technology Center (PETC). The project was initially for a duration of 18 months with an approved budget of $2 MM. Later, the project was extended in two steps to mid-December 1992. A proposal is in place with DOE/PETC to relax the design basis for Baseline by including higher space velocity for coal liquefaction reactor design basis. This will be referred to as the Improved Baseline case and is scheduled to be completed by mid-December 1992. The study is under DOE contract No. DE-AC22 90PC89857.

The primary objective of the study is to develop a computer model for a base line direct coal liquefaction design based on two stage direct coupled catalytic reactors. This primary objective is to be accomplished by completing the following:

- A base line design based on previous DOE/PETC results from Wilsonville pilot plant and other engineering evaluations
- A cost estimate and economic analysis
- A computer model incorporating the above two steps over a wide range of capacities and selected process alternatives
- A comprehensive training program for DOE/PETC Staff to understand and use the computer model
- A thorough documentation of all underlying assumptions for Baseline economics, and
- A user manual and training material which will facilitate updating of the model in the future

The progress made during any particular quarter is published in a quarterly report following the duration of the quarter. The report consists of the following four sections:

- Introduction
- Summary
- Technical Progress Report (By Tasks)
- Key Personnel Staffing Report.

Introduction (Continued)

Any confidential information will be presented in the quarterly report as a separate section under the heading "confidential". As agreed upon by DOE/PETC, information included in the confidential section will be treated confidential by DOE/PETC and its contractors.

This report is Bechtel's eighth quarterly progress report and covers the period of March 16, 1992 through June 21, 1992.

2. SUMMARY

Effective May 16, 1990, Bechtel initiated this study, with Amoco as subcontractor, as an assignment from the U.S. Department of Energy (DOE)'s Pittsburgh Energy Technology Center (PETC). The objective of the study is to develop a computer model for a Baseline direct coal liquefaction design based on two stage direct coupled catalytic reactors. The study was for a period of 18 months which was extended later to mid-December 1992.

This is Bechtel's eighth quarterly progress report and covers the period (as requested and approved by DOE/PETC) of March 16, 1992 through June 21, 1992. This reporting period was previously covered by three already published monthly status reports.

The report contains accomplishments made during this time period in all the Tasks scheduled for the period i.e., Tasks I through VI. As per schedule, the major focus, however, was on Task II, III, IV and V. Therefore, the accomplishments included in this report are predominantly for these four tasks.

The accomplishments are presented in the report on Task by Task basis for all the Tasks covered during this reporting period.

Task I

- In Task I (which defines the project) the Project Management Plan Draft Report was completed and subsequently updated incorporating the comments and suggestions of DOE/PETC and their contractors. The final version was sent to DOE/PETC for their approval and subsequently published in August, 1990. The approved copy was the deliverable for the Task.

- Project Management Plan report covers the overall scope of work, the methodology of managing the cost and schedule of the project (configuration management), program administration, the deliverables during various phases of work and the definition of the Baseline configuration.

Task II

Task II which concerns the development of the Baseline design of the liquefaction complex has been completed and the results have been published in three volumes during the last quarterly progress reporting period (December 23, 1991 through June 21, 1992). Any update and results reflecting fine tuning with modeling effort will be included in the corresponding portions of the final project report.

Summary (continued)

Task III

Task III concerns the development of the cost estimate and economics for the Baseline design and options for the coal liquefaction facility.

- During this reporting period, based on the DOE/PETC/Bechtel/Amoco review meeting of February 24-25, 1992 capital cost estimates for the Baseline design as well as all seven options were completed for two different scenarios. These scenarios are for: 1) the First Plant and, 2) Nth plant. In addition, during this period, the capital cost and operating requirements for the various options are being fine-tuned.

- In addition, during this reporting period a draft Topical/Task III report (in 2 volumes) containing capital cost and operating requirements for the Baseline and options were completed and published. The remaining volume (Volume III) of this report containing economics will be developed after the Improved Baseline Case is developed following DOE/PETC's approval of the pending proposal for such a case.

Task IV

- Task IV which concerns the development of the mathematical algorithms and models was completed. The final task report was issued the first week in October, 1991.

Task V

Task V involves developing the ASPEN process simulation model of the Baseline design.

- The ASPEN computer model had been tuned to match the Baseline design. Capital cost changes reflecting recommendation of the DOE/PETC/Bechtel/Amoco February, 1992, review meeting have been integrated.

- The ASPEN based kinetic model is being tuned to match the Baseline design. Testing of the model is in progress.

- Each user FORTRAN block model in the simulation has been elementally balanced, although an overall elemental balance is not reported by the computer model. As a part of SSI's subcontract, two subroutines for retrieving and loading pseudocomponent properties from the internal ASPEN storage for transfer from one process model to another have been developed and delivered. However, these new subroutines require Version 8 of ASPEN/SP, and cannot be used with the present production version of ASPEN. Thus, integration of the subroutines into the current models will not be feasible at this stage.

- The tuning of the model for the various option cases is continuing. In particular, Options 5, 6 and 7 were completed. Option 5 relates to fluid coking of the vacuum bottoms, Option 6 refers to steam reforming of natural gas plus Fluid Bed Combination (FBC) for hydrogen production, and option 7 involves naphtha reforming.

- At DOE's request, the model was revised to contain the costs for the "Nth plant" scenarios rather than the "First Plant" scenarios. The draft Topical Report for Task 5 is being revised incorporating this change.

- Economics model based on Lotus 1-2-3 spreadsheets has been revised to incorporate the updated set of key assumptions based on DOE/PETC's input. Documentation needs to be revised reflecting these changes.

- During this period a draft of Volume I and Appendix I of the Topical/Task report for Task 5 was completed. Volume I contained documentation for 1) the Baseline design and cost estimate model for the "First Plant" case and 2) the Lotus 1-2-3 spreadsheet economic model and 3) how to use it.

Task VI

This task concerns the development of a training manual and a training course for the process simulation model. A complete draft of the documentation has been completed and sent out for internal as well as DOE/PETC's review.

3. TECHNICAL PROGRESS (BY TASKS)

In order to carry out this Study efficiently, the Study has been divided in seven major tasks. Task I defines the project. Task II develops the Baseline design. Task III develops the capital, operating and maintenance costs. Task IV develops the mathematical model necessary for the process computer simulation model. Task V develops and verifies the process simulation model. Task VI documents the process simulation model and training. Task VII is a level of effort task for project management, technical coordination and other miscellaneous support functions.

During this reporting period (March 16, 1992 through June 21, 1992) several accomplishments were made in Tasks II, III, IV, V and VI. These accomplishments are included in this report task by task.

Task I was completed during the first quarterly reporting period. The accomplishment of Task I was documented in the Project Management Plan published in August, 1990. It was also presented in the first quarterly report, covering the period of May 16, 1990 through August 19, 1990).

3.1 TASK I

Task I defines the scope and the methodology of accomplishing the project. It sets the objectives of the project and defines the paths to accomplish those objectives.

As mentioned earlier in Section 3, Task I was completed during the first quarterly reporting period and accomplishments were documented in the Project Management Plan issued in August, 1990.

The Project Management Plan report is comprised of the following 9 sections:

- Executive Summary
- Background/Introduction
- Study Objective
- Overall Scope Of Work
- Configurational Management
- Program Administration
- Deliverables
- Baseline Configuration
- Appendix/Project Procedure Booklet
  List Of Contents

The report completing Task 1 was published on time schedule. Detailed accomplishments of Task I were included in the first quarterly report (May 16, 1990 through August 19, 1990) of the project.

3.2 TASK II

Task II concerns the development of the Baseline design of the liquefaction facility. This part of the study includes the acquisition of process licensors information, incorporation of various processing options into the design, and developing the design of the on-site processing units and offsite facilities (including storage and loading, utilities, and waste handling).

In this task certain plants are handled as packaged plants (or blocks) with an overall heat and material balance only.

3.2.1 STATUS UPDATE

The final Topical/Task report for task II is divided into three volumes. Volumes I and II contain the information on the Baseline design while volume III covers the options (alternates). Volumes I and II of the report were published during the quarter of September 16, 1991 through December 22, 1991 reporting period, whereas Volume III of the report, both draft and the final version were published During December 23, 1991 through March 15, 1992 reporting period.

3.3 TASK III

Task III concerns the development of the cost estimate and economics for the base-line design and the alternates for the coal liquefaction facility. This part of the study includes the compilation of equipment and utilities summaries, development of scaling factors for equipment sizes and plant costs, and development of the estimates for capital cost, working capital, and owner's costs. Work to perform the economic analyses includes the workup of the manpower requirements and operating costs for the Baseline design and for the options and the completion of sensitivity studies.

In this task plants are handled as packaged plants or blocks for the purpose of capital investment, and operating costs as well as overall capacity scale-up.

3.3.1 First Plant and Nth Plant Concepts

During February 24 and 25, 1992 DOE/PETC project review meeting at Naperville, Illinois, discussion was carried out on the "First Plant" and "Nth Plant" concepts. These concepts were described in the last quarterly report and are again presented below:

For any developing technology where the first commercial plant has not been built, there is a period of time certain items are initially assumed and later revised downward as the technology's commercial history is established. Such items are:

1. Design Basis including scale-up considerations (from the plant capacity at which the technology was proven to the capacity of the commercial plant).

2. Assumed design overcapacity factors which take the form of sparing of whole production trains. These over capacity factors have a direct impact on the onstream factor.

3. Project Schedule

The First plant concept is thus self-explanatory. It refers to the first commercial plant with a degree of over design to meet the name plate capacities and product specifications.

The period of time between the first commercial plant and the plant at which the technology commercial maturity is normally designated as N years. Thus the Nth plant is that commercial plant built N years after the first commercial plant for which the technology basis, plant design and operation are well known.

The focus of this task (Task III) is to define and develop the Nth plant economics, as requested by DOE.

The Nth plant economics are defined as the economics of the Nth plant which has the following characteristics:

1. requires lowest reasonable plant cost contingency;

2. contains no spare trains;

3. incurs the lowest reasonable engineering cost;

4. requires the lowest possible project schedule to erect and start-up;

5. technology has matured to the point that the Nth plant overall stream factor of the complex remains the same as that of the First plant.

Cost estimates for the Baseline and for all seven options following these concepts were completed during this reporting period.

3.3.2 Capital Cost Estimates for the Base Case

The methodology to 1) develop the capital cost for each inside battery limit (ISBL) plant and each out side battery limit (OSBL) plant and 2) ultimately calculate the installed capital costs for the entire complex are discussed below:

- Capital cost for each ISBL plant as well as OSBL plant was calculated by summing up the estimated costs of five components (i.e. major equipment, bulk material, sub contracts, direct labor and distributables).

- Allocate capital costs for OSBL plants to each ISBL plant capital costs.

- Include the prorated portion of the home office, fee and contingency to the adjusted costs as obtained in step above to calculate the installed capital costs for each ISBL plant.

- Sum up the installed capital cost for each ISBL plant to obtain the installed capital cost for the entire liquefaction complex.

Capital cost estimates for the Baseline case were obtained for the "First Plant" as well as for the "Nth Plant" concept. Results are presented in Tables 3.1 and 3.2 respectively.

TABLE 3.1

CAPITAL COST FOR THE COMPLEX BASE LINE FOR THE FIRST PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	91000	126400	157800
1.4	105000	146000	182100
2	1118600	1554900	1940700
3	25300	35100	43800
4	15600	21700	27100
5	74000	102800	128300
6	152600	212200	264800
8	42200	58700	73300
9	316300	440000	548700
10	191000	265500	331400
11	46700	64900	81000
38	40100	55800	69600
39	13300	18500	23100
TOTAL	2231700	3102500	3871700

TABLE 3.2

CAPITAL COST FOR THE COMPLEX BASE LINE FOR THE NTH PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	91000	131000	160800
1.4	87500	126000	154600
2	932200	1343000	1647800
3	25300	36400	44700
4	15600	22500	27600
5	74000	106500	130700
6	152600	220000	269800
8	42200	60800	74600
9	263700	380000	465900
10	191000	275000	337700
11	46700	67200	82500
38	40100	57800	71000
39	13300	19200	23500
TOTAL	1975200	2845400	3491200

3.3.3 Capital Cost Estimates for Options

During this reporting period the methodology to develop the capital cost estimates was completed. This was followed by developing the cost estimates for each option. The preliminary results on capital cost thus estimated are included in the confidential section of the report, whereas the methodology utilized for the capital cost estimates for various options is presented here:

Capital cost for each option was estimated by:

- Estimating the capital costs for the directly affected plant.
- Adjusting the capital costs for the indirectly affected plant
  - Capital costs adjustment for each of the indirectly affected plant was achieved by scaling the base case cost based on throughput
- Installed cost for the entire complex for each option as calculated following the methodology discussed in Section 3.3.2. The results for the "First Plant" Scenario are summarized in Tables 3.3 through 3.9 and those for the "Nth Plant" scenario are shown in Tables 3.10 through 3.16.

TABLE 3.3

CAPITAL COST FOR THE COMPLEX
OPTION 1 FOR THE FIRST PLANT

Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	127600	175100	218600
1.4	102500	140700	175600
2	1060000	1455200	1816300
3	25300	34700	43300
4	15600	21400	26700
5	74000	101500	126700
6	152600	209600	261600
8	36700	50400	62900
9	369000	506600	632200
10	191000	262200	327300
11	58300	80100	100000
38	40100	55000	68600
39	13300	18200	22700
TOTAL	2266000	3110700	3882500

TABLE 3.4

CAPITAL COST FOR THE COMPLEX OPTION 2 FOR THE FIRST PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	368900	506400	632000
1.4	101500	139400	173900
2	967300	1327900	1657400
3	25300	34700	43300
4	15600	21400	26700
5	73900	101500	126700
6	152600	209600	261600
8	27600	37800	47200
9	369000	506600	632200
10	191000	262200	327300
11	58300	80100	100000
38	39900	54800	68400
39	13200	18100	22600
TOTAL	2404100	3300500	4119300

TABLE 3.5

CAPITAL COST FOR THE COMPLEX OPTION 3 FOR THE FIRST PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	86600	118900	148400
1.4	105000	144100	179900
2	1139200	1563900	1952000
3	23800	32600	40700
4	12900	17700	22000
5	64800	88900	111000
6	161400	221600	276600
8	53700	73700	91900
9	311500	427700	533800
10	190700	261900	326800
11	43800	60100	75100
38	39800	54600	68200
39	13200	18100	22600
TOTAL	2246400	3083800	3849000

TABLE 3.6

CAPITAL COST FOR THE COMPLEX OPTION 4 FOR THE FIRST PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	90900	124800	155800
1.4	105000	144100	179900
2	1118600	1535600	1916700
3	25300	34700	43300
4	15600	21400	26700
5	74000	101500	126700
6	152600	209600	261500
8	42200	58000	72400
9	316300	434200	541900
10	191000	262200	327300
11	46700	64100	80000
38	40100	55100	68800
39	13300	18300	22800
TOTAL	2231600	3063600	3823800

TABLE 3.7

CAPITAL COST FOR THE COMPLEX OPTION 5 FOR THE FIRST PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	80000	109900	137200
1.4	105000	144100	179900
2	1118600	1535600	1916600
3	21100	28900	36100
4	12900	17700	22000
5	61700	84800	105800
6	134400	184500	230300
8-02	161100	221100	276000
9	261300	358800	447800
10	164900	226400	282600
11	39500	54200	67600
38	37800	51900	64700
39	13100	18000	22500
TOTAL	2211400	3035900	3789100

TABLE 3.8

CAPITAL COST FOR THE COMPLEX OPTION 6 FOR THE FIRST PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	75800	101600	129700
1.4	105000	140600	179600
2	1118400	1498500	1913400
3	25200	33800	43200
4	15600	20900	26700
5	74000	99100	126500
6	152400	204200	260700
8	42200	56600	72200
9-01	204300	273800	349600
11	29300	39300	50200
38	37900	50800	64800
39	16500	22100	28200
TOTAL	1896600	2541300	3244800

TABLE 3.9

CAPITAL COST FOR THE COMPLEX OPTION 7 FOR THE FIRST PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	89300	122700	153100
1.4	105000	144100	179900
2	1118600	1535600	1916600
3	25800	35400	44200
4	15600	21400	26700
5	73900	101500	126700
6	161600	221800	276800
7	30700	42100	52600
8	42200	58000	72400
9	298100	409200	510700
10	180800	248200	309700
11	45600	62600	78100
38	39500	54200	67700
39	13300	18300	22800
TOTAL	2240000	3075100	3838000

TABLE 3.10

CAPITAL COST FOR THE COMPLEX OPTION 1 FOR THE NTH PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	127600	175100	214800
1.4	85400	117300	143900
2	883300	1212700	1487900
3	25300	34700	42600
4	15600	21400	26300
5	74000	101500	124600
6	152600	209600	257100
8	36700	50400	61900
9	263600	361800	443900
10	191000	262200	321800
11	46700	64100	78600
38	40100	55000	67500
39	13300	18200	22300
TOTAL	1955200	2684000	3293200

TABLE 3.11

CAPITAL COST FOR THE COMPLEX OPTION 2 FOR THE NTH PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	368900	506400	621300
1.4	84600	116100	142500
2	806100	1106600	1357700
3	25300	34700	42600
4	15600	21400	26300
5	74000	101500	124600
6	152600	209600	257100
8	27500	37800	46400
9	263600	361800	444000
10	191000	262300	321800
11	46700	64100	78600
38	39900	54800	67200
39	13200	18100	22200
TOTAL	2109000	2895200	3552300

TABLE 3.12

CAPITAL COST FOR THE COMPLEX OPTION 3 FOR THE NTH PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	86600	118900	145900
1.4	87500	120100	147300
2	996800	1368400	1679000
3	23800	32600	40100
4	12900	17700	21700
5	64800	88900	109100
6	161400	221600	271900
8	53700	73700	90400
9	259600	356400	437300
10	190700	261900	321300
11	43800	60100	73800
38	39800	54600	67000
39	13200	18100	22200
TOTAL	2034600	2793000	3427000

TABLE 3.13

CAPITAL COST FOR THE COMPLEX OPTION 4 FOR THE NTH PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	90900	124900	153200
1.4	87500	120100	147300
2	932200	1279700	1570100
3	25300	34700	42600
4	15600	21400	26300
5	74000	101500	124600
6	152600	209500	257100
8	42200	58000	71100
9	263600	361800	444000
10	191000	262200	321800
11	46700	64100	78600
38	40100	55100	67600
39	13300	18300	22400
TOTAL	1975000	2711300	3326700

TABLE 3.14

CAPITAL COST FOR THE COMPLEX OPTION 5 FOR THE NTH PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	80000	109900	134800
1.4	87500	120100	147300
2	932200	1279700	1570100
3	21100	28900	35500
4	12900	17700	21700
5	61700	84800	104000
6	134400	184500	226400
8	161100	221100	271300
9	217800	299000	366800
10	164900	226400	277800
11	39500	54200	66500
38	37800	51900	63700
39	13100	18000	22100
TOTAL	1964000	2696200	3308000

TABLE 3.15

CAPITAL COST FOR THE COMPLEX OPTION 6 FOR THE NTH PLANT			
Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	75800	101600	124600
1.4	87500	117200	143800
2	932000	1248700	1532200
3	25200	33800	41500
4	15600	20900	25600
5	74000	99100	121600
6	152400	204200	250500
8	42200	56600	69400
9-01	204300	273700	335900
11	29300	39300	48200
38	37900	50800	62300
39	16500	22100	27100
TOTAL	1692700	2268000	2782700

TABLE 3.16

CAPITAL COST FOR THE COMPLEX
OPTION 7 FOR THE NTH PLANT

Plant #	ISBL Plant Field Costs 1000$	ISBL Plant Adj. With OSBL Costs 1000$	Installed Plant Costs 1000$
1	89300	122600	150500
1.4	87500	120100	147300
2	932200	1279700	1570100
3	25800	35400	43400
4	15600	21400	26300
5	73900	101500	124600
6	161600	221800	272100
7	30700	42100	51700
8	42200	58000	71100
9	248400	341000	418400
10	180800	248200	304500
11	45600	62600	76800
38	39500	54300	66600
39	13300	18300	22400
TOTAL	1986400	2727000	3345800

3.3.4 Economics and Sensitivities on Economics

The economic analysis to determine the Equivalent Crude Oil Price (ECOP) in $/bbl was carried out with a LOTUS 1-2-3 spread sheet model developed on the basis of following key assumptions:

Years of construction	4
Years of operation	25
Depreciation, years	10
Maintenance, % initial capital	1
Working capital, % revenue	10
Working capital, % liquid	50
Owner's cost, % initial capital first year operation	5
Bank interest rate	8
Federal income tax rate, %	34
Percent equity	25
Percent IRR on equity	15
General inflation %	3
Raw material price escalation	same as general inflation of 3%
State Tax	0
SCP [1]	1.07

(1) Syncrude Premium

The results of the economic analysis are given in Table 3.17. The Baseline design case requires an equivalent crude oil price of $38.55. A 25% reduction in plant capital costs reduces the ECOP by $5.90/bbl whereas a 25% reduction in raw material costs decreases the ECOP by $2.95/bbl. Other results of sensitivity analysis are shown in the same table.

For the best optional case where hydrogen is generated by natural gas reforming, the crude equivalent price is $36/bbl. However, as expected, this case is more sensitive to natural gas price. A 25% increase in natural gas price would reduce its $2.55/bbl advantage over the Baseline case to only $0.65/bbl.

TABLE 3.17
Sensitivity Studies

Item	Base Value	Sensitivity Case		
		Change	$/bbl	Delta
DOE Base Case			38.55	
Total Installed Capital, MM$	3491	+10%	40.90	+2.35
		+25%	44.45	+5.90
		-10%	36.20	-2.35
		-25%	32.65	-5.90
Raw Material Cost				
Coal, $/ton	20.5	+25%		
Natural Gas, $/MM BTU	2.00	+25%	41.45	+2.90
Raw Material Cost				
Coal, $/ton	20.5	-25%		
Natural Gas, $/MM BTU	2.00	-25%	35.65	-2.95
Raw Material Cost				
Coal, $/ton	20.5	+25%	40.85	+2.30
Raw Material Cost				
Natural Gas, $/MM BTU	2.00	+25%	39.20	+0.65
Syncrude Premium	1.07	1.27	32.40	-6.15
Owner's Equity, %	25	+100%	42.20	+3.65
Feed/Product Price Escalation %/year				
Coal	3	4.6		
Natural Gas	3	6.5		
Crude Oil	3	5.9	29.85	-8.70
Increased Liquid Yields, bbl/day				
Naphtha	19195	+10%		
Light Distillate	7803	+10%		
Heavy Distillate	21635	+10%		
Gas Oil	13310	+10%	35.05	-3.50
Hydrogen Production by Steam Reforming of Natural Gas,				
with base natural gas price of $2.00/MM BTU			36.00	-2.55
with natural gas price of $2.50/MM BTU			37.90	-0.65
SCP of 1.27			30.25	-8.30
Coal Price $25.62 (+25%)			37.65	-0.90

3.4 TASK IV

Task IV concerns the development of the mathematical algorithms and models for equipment sizing, scale-up, costing, and train duplication for incorporation into the ASPEN/SP process simulation model being developed in Task V.

3.4.1 Status of Task IV

The final topical/task report for Task IV was published in October 1991.

3.5 TASK V

Task V concerns the development of the ASPEN process simulation model of the Baseline design. The model will produce complete heat and material balances, elemental balances around each plant and the entire process complex, a major equipment list and outline specifications for Plant 2, utility requirements, capital cost for all plants, and a discounted cash flow economic model for the total complex. The model will be suitable for studying technology advances and options in a case study approach. The model will not include optimization capabilities.

During this reporting period several accomplishments were made in this task. These accomplishments are listed below.

- The ASPEN computer model had been tuned to match the Baseline design. Capital cost changes reflecting recommendation of the DOE/PETC/Bechtel/Amoco February, 1992, review meeting have been integrated.

- The ASPEN based kinetic model is being tuned to match the Baseline design. Testing of the model is in progress.

- Each user FORTRAN block model in the simulation has been elementally balanced, although an overall elemental balance is not reported by the computer model. As a part of SSI's subcontract, two subroutines for retrieving and loading pseudocomponent properties from the internal ASPEN storage for transfer from one process model to another have been developed and delivered. However, these new subroutines require Version 8 of ASPEN/SP, and cannot be used with the present production version of ASPEN. Thus, integration of the subroutines into the current models will not be feasible at this stage.

- The tuning of the model for the various option cases is continuing. In particular, Options 5, 6 and 7 were completed. Option 5 relates to fluid coking of the vacuum bottoms, Option 6 refers to steam reforming of natural gas plus FBC for hydrogen production, and option 7 involves naphtha reforming.

- At DOE's request, the model was revised to contain the costs for the "Nth plant" scenarios rather than the "first plant" scenarios. The draft Topical Report for Task 5 is being revised incorporating this change.

- Economics model based on Lotus 1-2-3 spreadsheets has been revised to incorporate the updated set of key assumptions based on DOE/PETC's input. Documentation needs to be revised reflecting these changes.

- During this period a draft of Volume I and Appendix I of the Topical/Task report for Task 5 was completed. Volume I contained documentation for 1) the Baseline design and cost estimate model for the "First Plant" case and 2) the Lotus economic model and 3) how to use it.

3.6 TASK VI

Task 6 concerns the development of a training manual and a training course for the process simulation model. The training course will include an overview of the system, modification of the reporting system, interfacing user models, modification of chemical properties, use of the cost and economics modules, specifying flowsheets, streams, components, properties, and convergence. Trainees will be instructed through the use of case study example problems.

- The ASPEN training course was conducted as per schedule during the week of March 23, 1992 at the DOE/PETC facilities in Pittsburgh.

- A first draft of the documentation of Task 6, the training manual, was completed and was used for the DOE/PETC training session.

- Topical/Task draft report for Task VI is issued for DOE/PETC's comments.

4. KEY PERSONNEL STAFFING REPORT

Key Personnel staffing report for this reporting period (March 16, 1992 through June 21, 1992) as required by DOE/PETC is included in Table 4-1 shown below.

Table 4-1
Key Personnel Staffing Report

Duration of Quarter **From March 16, 1992 to June 21, 1992**

Name of Key Person	Function	% Time Spent*
Bechtel:		
S. N. Habash	Project Manager	57
S. K. Poddar	Technical/Project Coordinator	77
T. J. Reynolds	Project Secretary	55
Amoco:		
J. J. Nicholas	Project Manager	10
S. J. Kramer	Principal Investigator	66

* (Number of hours spent/total available working hours for March 16, 1992 through June 21, 1992) x 100.